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THE PACIFIC FLATHEAD BORER

By H. E. Burke, *Senior Entomologist, Division of Forest Insects, Bureau of Entomology;*[1] Technical description of the mature larva, by A. G. Böving, *Senior Entomologist, Division of Taxonomy and Interrelations of Insects, Bureau of Entomology*

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INTRODUCTION

One of the worst enemies of newly planted deciduous trees and shrubs on the Pacific slope is the Pacific flathead borer, *Chrysobothris mali* Horn. This destructive borer kills or injures many trees and shrubs in the nursery and many more after they have been transplanted to the yard, park, cemetery, street, highway, or orchard. It has caused the total destruction of some plantings and prevented the growing of some species of trees and shrubs in certain localities. The writer has seen prune orchards in the foothills of the Santa Cruz Mountains where every tree was killed the first year, and has letters telling of apple orchards in the western foothills of the Sierras in which every tree was attacked. Some of these trees had as many as 15 borers under the bark of the main trunk, and many of them would have been killed if control methods had not been put into effect. Koebele (*24*),[2] in the first report on the economic importance of the species, stated that it was almost impossible to raise currants in the Santa Cruz Mountains because of the ravages of this pest.

[1] Assistance in the collecting of specimens and in the life-history work has been rendered by the following members of the staff of the Division of Forest Insects: F. C. Craighead, A. G. Angell, J. J. Sullivan, J. D. Riggs, Geo. Hofer, J. E. Patterson, and especially F. B. Herbert, W. E. Glendinning, and R. D. Hartman of the Palo Alto forest-insect laboratory. Mr. Hartman has been closely connected with the biological work and Mr. Glendinning with the economic work, especially with that relating to the highway planting. Credit for the photographs used in this bulletin is due to R. D. Hartman for Figure 2, A, B, D, E, and G, and Figures 3, 4, 5, 6, 7, 8, 10, and 11; to F. B. Herbert for Figures 1, A and B, and 2, C; to E. Morrow for Figures 2, F, and 12; and to J. E. Patterson for Figure 1, D.

[2] Referene is made by italic numbers to "Literature cited," p. 35.

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Numerous owners of shade trees report its destructive work. In at least one instance every tree planted in a yard in a large city was killed the first season. Numbers of young trees in plantings made along the State highways and along the streets of new town sites have been killed by the borers of this species.

As the pest is a native of this country and lives in many indigenous trees and shrubs, as well as in those introduced, its extermination is impossible.

This bulletin gives a summary of the data obtained from a study of the Pacific flathead borer made at intervals during the last 15 years.

HISTORY

Chrysobothris mali was named and described in 1886 by Horn (*21*). Specimens sent to Doctor Horn by L. E. Ricksecker from the Sacramento Valley, Calif., as infesting apple, and others collected in Owens Valley, Calif., which could not possibly have had this habit, are specifically mentioned. The distribution is given as California, Nevada, Utah, and Colorado.

The next report of the species was by Koebele (*24*) in 1890. Notes on the economic importance, life history, and habits were made and some methods of control recommended. From 1890 to 1904 several references were made to this insect as a fruit-tree pest by Cook (*13*, *14*, *15*) and Cockerell (*12*).

Allen (*1*, *2*), Wickson (*36*, *37*, *38*), and several others also wrote about it, confusing it with the common flat-headed borer of the East, *C. femorata* Fab. Between 1904 and 1917 various writers told of the damage done by the insect but considered the species to be *C. femorata.*

In 1912 Gibson (*18*) recorded specimens from Aweme, Manitoba, collected June 22, 1910, by Criddle. In 1917 Burke (*6*) showed that the species commonly injurious to trees and shrubs in California is *C. mali*, and Chamberlin (*7*) confirmed this for Oregon. In 1921 Chamberlin (*9*) gave a short account of the species with host plants, distribution, and other notes; Horne, Essig, and Herms (*22, pp. 4, 30, 34; 23, pp. 5, 37, 43*) mention it as an enemy of the apple, peach, plum, and prune; Black (*3*) reports it as a serious enemy of young apple trees in British Columbia; and Hendrickson (*19*) tells of the damage it does to the prune in California. Lovett and Barss (*26*) say that the borer occasionally is a serious enemy of currants and gooseberries.

The writer's work on this species began in Yreka, Calif., in 1911 with the discovery of the insect attacking a peach shade tree, and has continued through periods of residence in Placerville, Los Gatos, and Palo Alto.

IDENTITY

Numerous specimens of the beetle have been reared from various host plants and carefully examined, and there is no doubt that the species commonly found in fruit and shade trees on the Pacific coast is native and is the species described by Horn as *Chrysobothris mali.* Specimens from Baccharis considered at one time by Van Dyke (*33*) as a variety of *C. mali* were later determined as a distinct species and

described by him in 1923 as *C. bacchari* (*34*). *C. femorata* Oliv. is sometimes found in the same host with *C. mali*, and in all important cases a careful determination of the species should be made. Chamberlin (*8*) reported that, in the past, most of the work done by *C. mali* in the West had been charged to *C. femorata*. The two species are entirely distinct and can be distinguished easily by fairly prominent characters which are pointed out later in this bulletin.

ECONOMIC IMPORTANCE

IN THE NURSERY

The importance of this insect as a nursery pest (fig. 1, A–C) was first called to the writer's attention in May, 1918. A block of 1,500 young, vigorous-looking oriental plane trees about 10 feet high and 1½ inches in diameter at the base were examined in a nursery near San Jose, Calif. From this block, 258 trees had been cut because they were so badly injured as to be worthless, and many others were injured to some extent. The outer row of 156 trees had 91 infested with flathead borers. Another examination of the same block in July, 1918, showed numerous new infestations.

A reinspection of the nursery was made in May, 1919, and other varieties of trees were found to be infested. Out of several rows of European beech, 4 trees were killed, and in a row of 47 horse-chestnut, 21 were attacked, 4 being killed and 17 rendered unsalable. Another examination the following year revealed considerable injury to the upper sides of the branches of a large Mission fig tree. Out of a row of 12 Japanese flowering cherry trees 5 were killed, and in a row of mountain ash a number of trees were, or had been, infested. Some of these trees were killed by the girdling of the borers and others were so bady injured that they had been broken over by the wind.

In November, 1919, a nurseryman reported that he had lost from 9,000 to 10,000 2-year-old rosebushes which he was trying to hold over for a better market. He also had numerous horse-chestnut, tulip poplar, and weeping beech trees which had been attacked by this flathead borer. Many horse-chestnuts were injured but none were killed. Twelve out of 20 tulip poplars were killed and 20 out of 50 beech. An examination of this nursery made September 29, 1920, showed considerable new infestation in the beech trees and a number of mountain ash killed by the borers.

A row of 18 horse-chestnut trees examined November 9, 1921, contained 13 trees that showed the scars of old flathead-borer work and 12 that showed new infestation. Only 2 trees of the entire 18 had never been attacked. The rows of mountain ash examined September 29, 1920, now contained only 3 trees and these showed fresh borer work under the bark. A number of sweet-cherry trunks which had been used as standards for the flowering cherries were found to be infested by the flatheads.

Apparently borer damage occurs every year. In 1922 it was found in *Photinia serrulata* at Niles, Calif.; in 1923, in flowering pear at Edenvale; and in 1924, in sugar maple, flowering apple, and rose-flowering cherry at San Jose. At Edenvale 15 of a row of 106 flowering apple and 16 of a row of 135 flowering pear were attacked.

IN YARDS, PARKS, AND CEMETERIES

Trees and shrubs form the greatest attractions of yards, parks, and cemeteries, and their monetary value in the average locality ranges from a few dollars to thousands of dollars.

In his study of the Pacific flathead borer in numerous counties of California the writer has found a number of yard, park, and cemetery trees killed or injured by its work. Sometimes only a branch or a

FIG. 1.—Work of the Pacific flathead borer: A, Pile of young oriental plane trees killed by borers in a nursery near San Jose, Calif.; B, tree in same block newly infested at base; C, peach trees heeled into sawdust in a nursery, 95 per cent infested with the Pacific flathead borer; D, scar made by borer at base of an oriental plane tree in a park

side of the main trunk is killed, but at other times the entire plant dies from the girdling. Often places that are neglected for a single summer will lose trees and shrubs which have taken years to grow.

A number of young plane trees planted in one yard during May, 1920, were dying by August of the same year. The borers had girdled the trunks of these trees and also that of an English walnut planted in the same yard. Practically all of the copper beech in one park showed signs of old work as well as new infestation. Some trees were killed and others were so badly injured that they had to

be removed. The mountain ash is so often severely attacked that it is a question whether it should ever be planted in central California unless the conditions of soil, climate, and cultivation are specially favorable for its vigorous growth. *Cotoneaster horizontalis* was reported by gardeners at several places to have been so badly injured by the borers that its use as an ornamental shrub was discontinued. Similar reports have been received on the oriental shrub *Raphiolepis japonica*.

Among the most attractive sights in one cemetery during the springtime were two large Japanese weeping flowering cherry trees. Close examination showed that they looked ragged at the top, the upper sides of the weeping branches were covered with rough, cracked bark, and some of the smaller branches were dead. Under the cracked and dying bark were the mines and larvae of the Pacific flathead borer, sufficient proof that it was the species responsible for the trouble.

ALONG STREETS AND HIGHWAYS

Usually street and highway trees have less care and live under less favorable conditions than other shade and ornamental trees, which would naturally lead one to expect them to be more subject to injury than yard, park, and cemetery trees. As a matter of fact this is not usually true.

In the case of street trees, severe damage is more apt to occur where new towns or new additions to old towns are laid out, and the trees are planted before building takes place. In August, 1922, most of 200 Lombardy poplars and 100 oriental plane trees planted along the newly laid out streets of a San Joaquin Valley town near Merced, Calif., were found infested with borers.

IN THE ORCHARD

From the time of its original description by Horn (*21*) in 1886, *C. mali* has been found to be an enemy of orchard trees, especially those just transplanted. Some of the specimens upon which Horn based his description came from the apple, hence the name *mali*. Its injury to currants in the Santa Cruz Mountains was reported by Koebele (*24*), and other writers continually mention the species as an orchard pest, sometimes under the name of *C. mali* and sometimes under that of *C. femorata*.

A study of the species, carried on by the writer and his associates since 1911, indicates that there is scarcely an orchard planted in California which does not lose a few of its trees the first year from borer work. In some localities and with some varieties of trees the loss is slight, whereas in other localities and with a susceptible host the loss may run as high as 95 per cent.

In 1918, near San Lorenzo, Calif., the writer examined a 40-acre field of currants which were so badly infested with flathead borers that the owner intended to tear out the bushes and burn them.

From many localities come reports of injuries to apple trees. The trunks of young trees are girdled and the branches of old trees are attacked and killed or more or less injured. Apparently the injury

is greater in the mountain districts, probably because of the proximity of many native hosts. At the same time it is in these mountain localities that the principal apple orchards of California are located.

The following letter from Threerivers, Calif., illustrates what often happens to young apple orchards in the foothills of the Sierras:

> Last year I set out a fine young apple orchard of 1-year-old and 2-year-old trees on my farm near Three rivers, which is situated in the foothills of the Sierras at an elevation of 1,000 feet. The trees were all badly attacked by the borers, and their working covered the period of June, July, and August. * * * Some of the trees contained as many as 15 grubs. The attacks were practically all made between the ground and the first branches of the trees, but occasionally an attack was made just below the ground surface.

In September, 1924, an apple orchard near Felton, Santa Cruz County, was examined, and every tree of the 196 planted about February 1 was found killed by the borers. A similar condition was found at Corralitos, Monterey County. Both of these orchards are in the Santa Cruz Mountains, which are part of the Coast Ranges of central California.

Chrysobothris mali is also one of the most important pests of the various fruit trees of the genus Prunus, such as the plum, sweet cherry, sour cherry, peach, and apricot. Plum and prune seem to be more subject to attack than the others, and the writer has found well-grown as well as newly planted trees of all varieties killed by the borers.

In 1919, in a newly planted orchard of prunes near Los Gatos, 95 per cent of the trees were killed by the borer. In 1920 a newly planted apricot orchard near Simla lost 20 per cent in the same way. Both of these are in the principal orchard district, but close to large areas of native growth, which probably furnished the infesting insects. In practically all of the orchards of this section, which is in the famous Santa Clara Valley, some trees are killed or lose part of their branches every year from the work of the flathead borer.

Reports from other fruit-growing sections of California, such as the Sacramento and San Joaquin Valleys and the foothills of the Sierras, indicate that the injury is as common in these sections as it is in the Santa Clara Valley. Chamberlin (*9*) classes *C. mali* as an important enemy of orchard trees in Oregon.

IN THE FOREST

Flathead-borer injury to trees and shrubs in the native forest is similar to that in planted trees and shrubs, except that usually only a part of the plant is killed. The bark on one side of the trunk may be killed or an entire branch may die from the result of the boring, but rarely does the work kill the main trunk as it does in the case of the planted trees.

Observations made in the forests of southern Oregon, northern California along the Sierras to the Sequoia National Park, and in the Coast Ranges from Eureka to Santa Barbara, indicate that the greatest damage is done to the alder, hazel, and mountain mahogany. Dead spots due to the work of flathead borers have been found on the trunks of the alder, several species of oak, hollyleaf cherry, wild plum, pea chaparral, wild lilac, madrone, and blue gum; dead roots killed by the same insect have been found on the canyon live oak and

blue gum; and dead branches on the willow, alder, hazel, several species of oak, sycamore, flowering currant, mountain mahogany, Christmas berry, wild plum, hollyleaf cherry, Indian plum, buckeye, coffee berry, evergreen buckthorn, and several species of manzanita.

Apparently the principal breeding grounds of the species are scattered throughout the forest, a few breeding in this spot and a few in that, although numbers of individuals are sometimes reared from a single sycamore, willow, or mountain mahogany.

COST OF PROTECTION

As the insect does so much damage to planted trees, an enormous amount of money is spent every year for insecticides, whitewashes, mechanical protectors, and various treatments used in the attempt to prevent its ravages. Much of this should be charged against the species in any consideration of its economic importance. However, some of the methods used prevent sunburn and otherwise benefit the trees.

DISTRIBUTION

The species is common over nearly all of California and has been reported from Canada, Washington, Oregon, Nevada, Utah, Colorado, Texas, New Mexico, and Arizona. In the original reference (1886) Horn (*21*) gives California, Nevada, Utah, and Colorado as its range. In 1890 Koebele (*24*) found it in the Santa Cruz Mountains of California. In 1902 Cockerell (*12*) listed it from Simmons, Ariz.; and in 1902–3 Snow (*30*) found it in Coconino and Yavapai Counties, Ariz. Gibson (*18*) records the species from Aweme, Manitoba, Canada, in his Entomological Record for 1911. In 1917 Burke (*6*) added Oregon to the list, and in 1921 Chamberlin (*9*) added Washington and New Mexico. In a letter to the writer Chamberlin also reports that H. W. Wenzel of Philadelphia has specimens in his collection labeled "Davis Mountains, Texas." If these specimens are true *mali* this record would add another State to the list.

There are specimens in the forest-insect collection of the United States Bureau of Entomology from the following localities: Keno, Klamath Falls, and Steinman, Oreg.; Aldercroft, Alum Rock, Beverly Hills, Briggs, Bray, Cedar Mountain (Alameda County), Confidence, Corallitos, Cow Creek (Stanislaus National Forest), Cupertino, Davis, Edenvale, Farmersville, Felton, Glenwood, Guadaloupe, La Fayette, Los Gatos, Marysville, Merced, Milpitas, Niles, North Fork, Palo Alto, Placerville, Planada, Pinecrest, Redwood City, Sacramento, San Geronimo, San Jose, San Lorenzo, Saratoga, Sequoia National Park, Shingle Springs, Sisson, State Redwood Park (Santa Cruz County), Threerivers, White Hall, Woodside, Wrights, Yosemite National Park, and Yreka, Calif.

The altitudinal range is also broad, specimens having been found from tidewater to the high Sierras (6,000 feet).

FOOD PLANTS

The food plants, both native and introduced, are numerous, and the insect probably will be found to attack practically all of the deciduous

fruit and shade trees. The writer and his associates have taken specimens from the trees and shrubs listed below.

SALICACEAE

Salix laevigata, smooth-leaf willow.
Salix lasiolepis, arroyo willow.
Salix babylonica, weeping willow.
Salix fragilis pendula, Meyer's globular-headed willow.
Populus deltoides, Carolina poplar.
Populus nigra italica, Lombardy poplar.

JUGLANDACEAE

Juglans regia, English walnut.

BETULACEAE

Betula alba, European white birch.
Alnus rhombifolia, white alder.

CORYLACEAE

Corylus californica, California hazel.

FAGACEAE

Fagus sylvatica purpurea, copper beech.
Quercus chrysolepis, maul oak.
Quercus californica, California black oak.
Quercus vaccinifolia, huckleberry oak.
Quercus agrifolia, California live oak.

ULMACEAE

Ulmus americana, American elm.
Ulmus scabra pendula, Camperdown elm.
Ulmus scabra huntingdoni, Huntingdon elm.

MORACEAE

Ficus carica, common fig.

MAGNOLIACEAE

Liriodendron tulipifera, tulip poplar.

LAURACEAE

Persea gratissima, avocado.

GROSSULARIACEAE

Ribes rubrum, cultivated currant.
Ribes sanguineum, California red-flowering currant.

PLATANACEAE

Platanus orientalis, European sycamore or oriental plane.
Platanus racemosa, California sycamore.

MALACEAE

Cotoneaster horizontalis, trailing cotoneaster.
Cotoneaster sp., cotoneaster.
Pyracantha coccinea lalandi, fire thorn.
Crataegus carrierei, thorn.
Cydonia oblonga, quince.
Pyrus communis, pear.
Malus sylvestris, apple.
Sorbus aucuparia, European mountain ash.
Raphiolepis japonica, raphiolepis.
Eriobotrya japonica, loquat.
Photinia arbutifolia, California Christmas berry.
Photinia serrulata, Chinese Christmas berry.

ROSACEAE

Rubus vitifolius, Logan blackberry.
Cercocarpus parvifolius, mountain mahogany.
Rosa sp., cultivated roses.

AMYGDALACEAE

Osmaronia cerasiformis, Indian plum or oso berry.
Amygdalus communis, almond.
Amygdalus persica, peach.
Prunus armeniaca, apricot.
Prunus cerasifera, cherry or Myrobalan plum.
Prunus domestica, plum, prune.
Prunus subcordata, Pacific plum.
Cerasus pendula, Japanese weeping rose-flowering cherry.
Cerasus avium, sweet cherry.
Cerasus vulgaris, sour or pie cherry.
Cerasus serrulata, Japanese flowering cherry.
Laurocerasus ilicifolia, hollyleaf cherry.
Laurocerasus laurocerasus, English laurel.

LEGUMINOSAE

Wisteria sinensis, Chinese wistaria.
Pickeringia montana, pea chaparral.

ACERACEAE

Acer rubrum, red maple.
Acer macrophyllum, Oregon maple.
Acer saccharum, sugar maple.
Acer saccharinum, silver maple.
Acer negundo, box elder.

HIPPOCASTANACEAE

Aesculus hippocastanum, European horse-chestnut.
Aesculus californica, California buckeye.

RHAMNACEAE

Rhamnus crocea, evergreen buckthorn.
Rhamnus californica, California coffee berry.
Ceanothus cuneatus, buckbrush.
Ceanothus sorediatus, mountain lilac.

MYRTACEAE

Eucalyptus globulus, blue gum.

ERICACEAE

Arbutus menziesii, madrone.
Arctostaphylos tomentosa, woolly manzanita.
Arctostaphylos mumularia, manzanita.

This list furnishes a record of at least 70 host species belonging to 40 genera in 21 different plant families. Malaceous and rosaceous species appear to be attacked by *C. mali* more often than any other plants, although the heaviest infestations so far noted by the writer have been in the mountain mahogany and California sycamore.

CHARACTERISTIC WORK

The characteristic work (fig. 2, A–G) of the Pacific flathead borer is a winding, shallow larval mine in the inner bark and outer wood of the host. This mine terminates in the outer wood in a flattened, oval pupal cell which opens to the outer surface by an oval exit hole. Usually the bark over the mine cracks and peels. In this case the boring beneath is plainly revealed. If the bark is thick no cracking results and the mine beneath remains concealed. Sometimes the mining causes a ridge to form in the bark over it and sometimes a depression. In small trees and in shrubs the mine and the pupal cell may extend through the heartwood, but in large trees they remain close to the surface. They may kill only a small spot of the bark, or they may encircle the trunk and kill the entire plant.

The boring may occur in any part of the bark from the root to the topmost branch. Usually, however, it occurs in the bark of the main trunk, especially in the case of the smaller trees. In weeping trees it occurs in the bark exposed to the direct sunlight by the bending down of the weeping branches.

INDICATIONS OF INJURY

New work of the flathead borer (fig. 3, A and B) is indicated by a slight flow of sap which makes a dark, wet spot on the bark. Later the bark may crack slightly and expose some of the borings. In some trees, especially those of the genus Prunus, there is a slight flow of gum. In many cases the area covering the wound becomes roughened.

As the mining progresses the bark falls off, leaving the wood exposed and often making ugly, cankerlike spots. (Figs. 2, A, D, and F.) The surface is uneven and roughened by the larval mines and is usually dotted with a number of holes made by the larvae in entering the pupal cells in the wood and by the adults in emerging from the cells. Finally the wood becomes weather beaten and checked, and, if the tree is not killed, the edges of the wound are overgrown by new bark. (Fig. 1, D.) The degree of healing depends on the number of years that have elapsed since the time of injury. Too often there is evidence of a succession of attacks and an enlargement of the wound.

To the horticulturist the indications of injury by the borer vary considerably. Sometimes the tree does not leaf out in the spring;

sometimes it leafs out and suddenly withers. All depends upon the extent of the injury, the time of the year it is caused, and the variety of the tree or shrub injured. If the damage is caused early in the spring, the tree wilts; if late in the summer, the tree sheds its leaves as usual but fails to leaf out the next spring.

FIG. 2.—Work of the Pacific flathead borer: A, Trunk of peach tree showing mine of borer near base; B, section of trunk of young apple tree killed by the borer, showing larval mines in wood and one under the bark, how the bark sometimes swells over the mine, and emergence hole of beetle near end of mine; C, branch of Lamarque rose girdled and killed by a single mine of borer; D, section of trunk of copper beech killed by borers, showing larval mines under the bark and emergence holes in wood and bark; E, section of prune branch showing exit holes of both *C. mali* and *C. femorata* beetles; F, section of English laurel branch killed by borer (the branch was tied into a knot several years previous); G, inside view of bark from trunk of young eucalyptus tree, showing mines and emergence holes

CAUSE OF THE ATTACK

Most of the writers on the subject say that sunburn is the principal cause of attack by the flathead borer. In some cases this may be true, but in the majority it certainly is not. For instance, in one apple orchard which came to the attention of the author and which

was planted in February every tree was attacked soon afterwards and was dead by the end of September. In another case a 40-acre orchard field which had been growing vigorously for several years was in

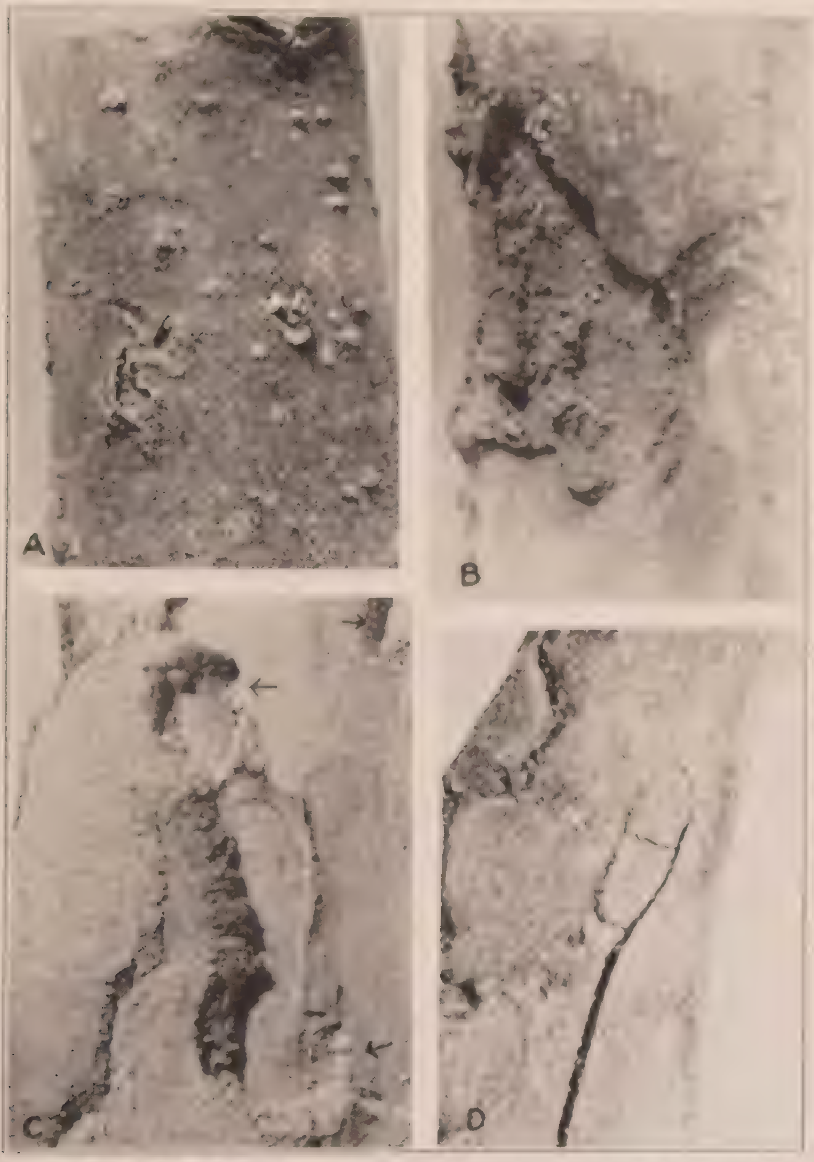

FIG. 3.—Work of the Pacific flathead borer: A, Work of small larva in outer bark of apple, showing sunken area over mine and point where larva entered from the egg. × 4; B, same as A with outer bark removed. × 4; C and D, sections of apple wood showing portions of mines and entrances to pupal cells. × 3.3 and 3

good bearing condition when finally attacked by the borers. It does not appear reasonable to believe that sunburn caused the attacks in either of these cases.

On the other hand, sunlight may be responsible for borer attacks on the exposed sides of the branches of weeping trees which are exposed to the direct rays of the sun. Even in this case, however, the fact that the beetle is sun loving and may attack the exposed branches to a greater degree because they furnish attractive haunts for the insect must be taken into consideration.

It is probably safe to say that practically no newly transplanted tree or shrub is 100 per cent healthy. If planted under favorable conditions of climate and soil some of them soon become comparatively normal, others take a much longer time, and some never become normal. In many cases the conditions actually observed in the field appear to bear out the supposition that trees physiologically below normal from any cause are more apt to be chosen by the beetle mother of the borer than are those in perfect or nearly perfect health. In many others, however, the trees attacked appeared to be normal and to be growing vigorously or at least as vigorously as many of those near by which might just as well have been selected.

All of the evidence obtained to date indicates that the Pacific flathead borer is likely to attack any tree or shrub of a susceptible species which has been disturbed from any cause. This would include practically every newly transplanted tree or shrub. From other investigations the cause of an attack appears to be more a question of the occurrence and abundance of the insect than of the condition of the trees, although those located in the bright sunshine are more apt to be chosen by the female for ovipositing.

TECHNICAL DESCRIPTIONS

THE ADULT

Horn (27, p. 97) described the adult or beetle stage (fig. 4, B, C, and E) of the insect as follows:

C. mali n. sp.—Form rather broad, subdepressed, color above variable from dark bronze to bright coppery [illegible] closely punctured in the male and with two median callosities and a chevron [illegible] at the end of the third costa (these often confluent), a third near the middle [illegible] submarginal ridge. Length 0.26–0.42 inch (*6.5–10.5 mm.*).

Male.—[illegible] at tip.

Female. Prosternum a little less closely punctate [illegible] arcuate, the middle and posterior straight, last ventral [illegible] circular emargination, the last dorsal sparsely punctate and [illegible]

The variation in surface color is fr[illegible] *femorata* to that with the entire surfac[illegible] less marked.

FIG. 1. Adult flathead beetles. A, Dorsal view of [illegible] B, dorsal view of male *C. mali*, × 8; C, left w[illegible] *rata* below, × 5.8; D, right elytron of *C. femorata*, × 6.7; [illegible] *mali*, × 6.7.

Specimens from the Sacramento Valley were sent me by M[illegible] as infesting apple trees; others collected in Owen's Val[illegible] have had that habit.

Occurs in California, Nevada, Utah, and [illegible]

In Horn's table the species is identified as havin[illegible] gin of the last ventral segment serrulate; the disk of th[illegible] its median line more or less sulcate, often with callosit[illegible] terior tibiae of male more or less arcuate, dilated [illegible]

depressed; the prosternum lobed, sometimes rather feebly; the median sulcus very feeble, linear or almost obliterated, the sides of the disk without obvious smooth or elevated spaces, the last ventral segment without submarginal ridge, the marginal groove feeble, the anterior tibia of the male dilated near the tip without obvious sinuation; the teeth of anterior femur serrulate; the ventral segments with distinct lateral smooth spaces; the last ventral segment of the female with small semicircular emargination.

Horn's description seems to have been made carefully and thoroughly, and, although several hundred specimens have been examined from various localities, very little variation from the description has been noted.

REVISIONAL NOTES

Body with scattered short white hairs above, dense long white hairs below, color more often bronzy below than cupreous; thorax nearly twice as wide as long; densely punctured spaces of the elytra sometimes dull, sometimes coppery; ventral segments with distinct [illegible] tufts of long hairs as well as distinct lateral callosities. Breadth 0.12 to 0.2 of an inch.

MALE

Front greenish; prosternum densely pubescent; pygidium coarsely punctate, broadly emarginate at apex; propygidium coarsely punctate, slightly depressed in center, smooth in front of depression; last ventral segment coarsely punctate, broadly semicircularly emarginate at apex; aedeagus subcylindrical, tapering gradually toward base, more abruptly toward apex, constricted near apex, lateral lobes united at base, [illegible] set off by the constriction [illegible], median lobe subfusiform, apex acute. (Fig. 5, B, F; fig. 6, B, F, J, and L.)

FEMALE

Front bronzy; prosternum moderately pubescent; pygidium coarsely punctate, narrowly semicircularly emarginate at apex; propygidium coarsely punctate, slightly grooved along median line, [illegible]; last ventral segment sparsely punctate, narrowly deeply notched at apex; ovipositor oblong, three times as long as broad, broadest just before apex [illegible]; cerci dark, trapezoidal. (Fig. 5, D and H; fig. 6, H and N.)

DIFFERENCES BETWEEN ADULTS OF MALI AND FEMORATA

Beetles of *Chrysobothris mali* (fig. 5, A-H; fig. 6, A-N) have the prosternum distinctly lobed in front and the basal half of the large tooth of the anterior femur smooth. Beetles of *C. femorata* have the prosternum truncate in front and the basal half of the large tooth of the anterior femur serrate. Males of *C. mali* have the distal portion of the anterior tibiae dilated, the pygidium not grooved, broadly emarginate at apex; the propygidium [illegible] at base, slightly depressed along median line; the lateral and median lobes of aedeagus [illegible]. Males of *C. femorata* have the distal portion of the anterior tibiae armed with small teeth, the pygidium [illegible], the propygidium [illegible] at apex and grooved along the median line; each lateral lobe of the aedeagus armed on the outer side near the apex with a large recurved spine and the median lobe armed on each side with [illegible] small recurved spines. Females of *C. mali* have pygidium narrowly semicircularly emarginate at apex; the last ventral segment narrowly, deeply notched at apex, and ovipositor three times as long as broad. Females of *C. femorata* have the pygidium narrowly, deeply notched at apex, and a ridge along the median line; the last ventral segment broadly but not deeply emarginate at apex and the ovipositor five times as long as broad.

THE EGG

Subcircular, flattened, wrinkled, whitish, opaque, 0.04 inch in diameter. Form varying with the crevice or depression in which it is deposited. (Fig. 7, A-D.)

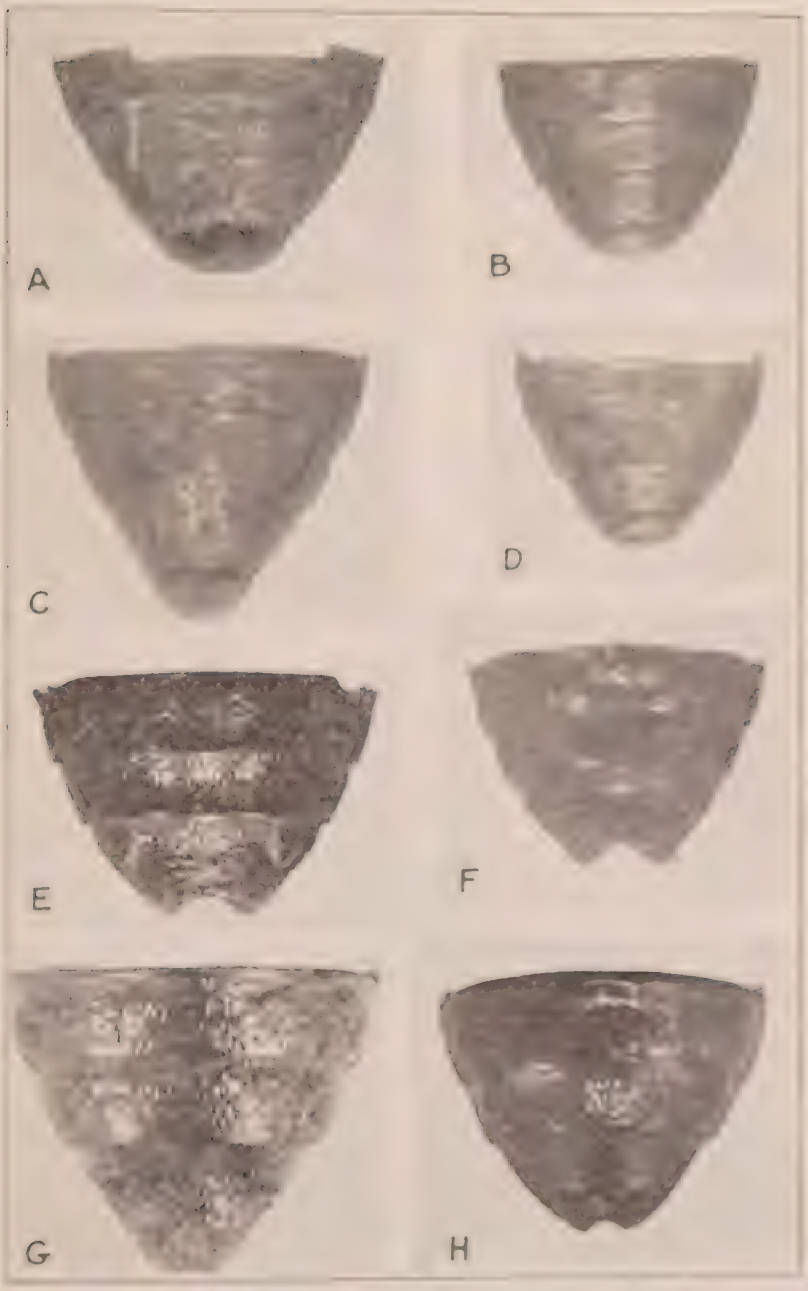

FIG. 5.—Comparison of terminal segments of abdomen of adult of *Chrysobothris femorata* and *C. mali*. Dorsal views: A, *Chrysobothris femorata*, male, ×9; B, *C. mali*, male, ×9; C, *C. femorata*, female, ×11; D, *C. mali*, female, ×11. Ventral views: E, *C. femorata*, male, ×11; F, *C. mali*, male, ×11; G, *C. femorata*, female, ×12; H, *C. mali*, female, ×12.

FIG. 6.—Comparison of characters of the beetles of *Chrysobothris femorata* and *C. mali*: A, Front of *Chrysobothris femorata*, male, clypeus acutely notched at middle, semicircular at each side, ×8.5; B, front of *C. mali*, male, clypeus broadly triangularly notched at middle, angular at each side, ×7.4; C, prosternum of *C. femorata*, not lobed anteriorly, ×7; D, prosternum of *C. mali*, lobed anteriorly, ×7; E, right front leg of *C. femorata*, male, tarsus removed, femur with large tooth denticulate on both edges, tibia toothed near apex, ×8; F, right front leg of *C. mali*, male, tarsus removed, femur with large tooth denticulate only on apical edge, tibia dilated at apex, ×8; G, right front leg of *C. femorata*, female, tooth of femur denticulate on both edges ×8; H, right front leg of *C. mali*, female, tooth of femur denticulate on both edges, ×8; H, right front leg of *C. mali*, female, tooth of view, ×7; J, aedoeagus of *C. mali*, ventral view, ×5.6; K, aedoeagus of *C. femorata* with lobes separated, each lateral lobe armed with a single recurrent tooth, median lobe denticulate on both edges, ventral view, ×7; L, aedoeagus of *C. mali* with lobes separated, lateral lobes unarmed, median lobe not denticulate, ventral view, ×5.6; M, ovipositor of *C. femorata*, dorsal view on left, ventral view on right, ×7.4; N, ovipositor of *C. mali*, dorsal view on left, ventral view on right, ×8.5

THE LARVA[1]

Larva (fig. 8, D; fig. 9, A and B) clublike, [illegible]

Length of [illegible] 5 mm.

Head (fig. 8, A and E) cordate, posteriorly deeply [illegible] parts with dark [illegible] chitinization.

Frons triangular, anteriorly with large and strong epistoma [illegible] two or three minute sensory spots; on the underside an almost circular condyle for each mandible. General color of epistoma brownish yellow with the margins and a fine longitudinal middle line darker; close to the latter on each side a short transverse row of three thick, short microscopical pegs (*p*). Frontal [illegible] of carina to the lateral ends of epistoma (*rt*), near basis of antenna and immediately behind the posterior border of epistoma about six minute setae [illegible] with a longitudinal series of one larger and two or three very minute setae.

Clypeus (fig. 8, F) very thin, [illegible]

Labrum (fig. 8, F) elongate, cuneiform, widest in front, about twice as long as wide, amber yellow; anterior margin slightly convex, antero-lateral corners rounded, both margin and corners densely beset with stiff, spiny hairs, two transversely placed well-developed setae present behind each of the antero-lateral corners; between these setae and slightly in front of them a short transverse series of three to four short, dark-colored pegs (*p*) placed closely together; midway on the lateral margins a single strong seta, and on each side near anterior margin of clypeus a large sensory puncture.

Antenna (fig. 8, A and I) inserted dorsally in an oblong, deep, posteriorly open cavity at end of epistoma, behind and exterior to the dorsal condyle for the mandible, short, three-jointed, with a large whitish, setose basal membrane; proximal joint (*1*) subcylindrical, well chitinized, brownish, distally densely setose; second joint (*2*) obliquely inserted on first, membranous, whitish subglobose, and densely setose with some of the setae comparatively strong; apical or third joint (*3*) minute, papillalike, yellowish, thinly chitinized, with clear, hard tip, inserted medianly on top of second joint and retractable into it, causing the latter to assume the form of a cup.

Mandible (fig. 8, B and C) broad, apically bidentate with pointed teeth (*d*, *r*); inner face with an oblong cavity having a single median longitudinal carina (*ca*); dorsal margin of inner face anteriorly armed with a single rather short tooth (*rt*) not extending so far forward as the apical teeth, ventral margin entire; a transverse ridge (*r*) on the anterior mandibular face produced into an acute, short tooth above the ventral condyle; ventral condyle (*vc*) excavated on ventral face into a deep fovea (*fc*); color of mandible brownish piceous distally, reddish brown at basis; setae two (or three), short, thin, on exterior face near basis.

Peristoma (the lateral parts of the mouth frame between the dorsal and ventral mandibular articulations) without a projecting [illegible] it [illegible]. A group of small dark [illegible]

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[1] [illegible] E, and [illegible] B, C, F, G, H, I, J, and K by A. G. Böving. The material on which the description is based is contained in two vials to be found in the United States National Museum, one of which is marked "Palo Alto, Calif., H. E. Burke," and the other "8 ix 1922, Cupertino, Calif., H. E. Burke."

grains (fig. 8, A and I, oc) situated posteriorly to the dorsal mandibular articulation and exteriorly to the antennal cavity may represent a reduced ocellus; one strong seta present near outer margin of this presumed ocellus.

Hypostoma (the ventral part of the mouth frame between the ventral mandibular articulation and the gula) light colored with anterior margin brownish. (Fig. 8, E, hy.)

Ventral mouth parts protracted; maxillary articulating area not differentiated.

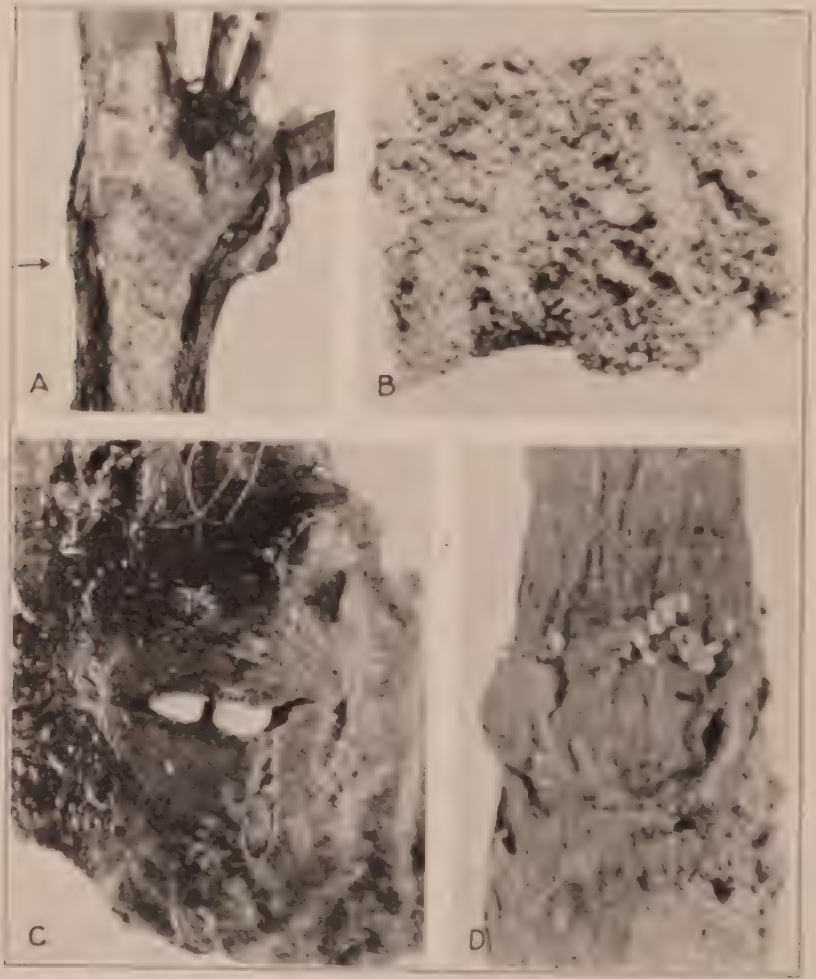

Fig. 7.—[illegible] of Raphiolepis and holes where young borers entered the wood. [illegible]

Maxilla (fig. 8, E) rather small; cardo (ca) membranous, large, subtrapeziform, broadest posteriorly, with three setae of moderate size situated closely together on a minute brownish plate posteriorly near the exterior margin; stipes (st) elongate, subovoid, with posterior two-thirds almost [illegible] and usually retracted into cardo; anterior third free, yellowish brown, densely covered with asperities and minute setae; mala (possibly galea) single, lobe-like, movable, about as long as first joint of palpus and half as wide, subcylindrical, distally obtuse with chitinous brownish exterior face and mem-

[illegible] flathead borer [illegible] A, head, dorsal view [illegible] ; *s*, transverse [illegible] rods of frons ; [illegible] scuto-scutellum ; E, head [illegible] ; *li*, ligula [illegible] ; *sm*, submentum ; *st*, stipes ; F, clypeus and labrum ; [illegible]

[illegible] with a few small setae and sensory punctures.

[illegible] along the middle line.

[illegible] zoidal, wedged in between and indistinctly separated from cardines.

[illegible]

FIG. 8.—Comparison of borers of *Chrysobothris femorata* and *C. mali*. A, Dorsal view of larvae, *Chrysobothris femorata* on left, *C. mali* on right, × 2; B, ventral view of larvae, *C. femorata* on left, *C. mali* on right, × 2; C, dorsal plate of prothorax of larva of *C. femorata*, × 7; D, same of *C. mali*, × 7; E, ventral plate of *C. femorata*, × 7; F, same of *C. mali*, × 7; G, dorsal view of pupa of *C. mali* which is about ready to transform to a beetle, × 3.8; H, ventral view of a recently formed pupa of *C. mali* in its cell in the wood of a peach tree, × 3.3.

[illegible] palpiger.

[illegible] and densely setose.

Hypopharynx membranous, generally naked anteriorly, however, with lateral [illegible] bridge lacking.

Oesophagus with six large, parallel, keel-shaped internal lobes.

Prothorax (fig. 8, D and L) transverse-orbiculate, distinctly larger and [illegible] than mesothorax and metathorax, [illegible] as wide as one of the median abdominal segments, depressed quadrate in transverse section; [illegible] covered with dashlike, appressed, irregularly serrated asperities (fig. 8, K) and near the margin small, conical granulae; dorsal shield paramedianly with two shining, light-colored and forward converging grooves, grooves anteriorly [illegible] surface and not reaching the front margin of the shield; ventral shield with a similar, but single and median groove extending from near the anterior margin backward over two-thirds of the shield, thus ending a considerable distance from the posterior margin. A lateral chordotonal organ not discovered in the present larva.

Mesothorax (fig. 8, D and L) considerably narrower and shorter than prothorax; scuto-scutellar area extending to the posterior margin of the segment, provided with a pair of indistinctly limited scansorial ampullae; pleural region indistinctly limited, no upper and lower horizontal grooves being present; [illegible] defined by a vertical, deep groove (*gr*) which continues on the dorsal and especially the ventral side. Sternal region simple.

Metathorax (fig. 8, D and L) slightly narrower and almost twice as long as mesothorax; build in general like mesothorax but spiracular area small and the spiracle reduced to a minute speck.

Pedal lobes (fig. 8, L, *pe*) indistinct, membranous, without any rudiments of legs or special setal armature; situated in prothorax immediately exterior to the ventral shield and in mesothorax and metathorax between the pleural and sternal regions.

First abdominal segment (fig. 8, D and L) [illegible] metathorax than with second abdominal segment, not more than two-thirds as long as the latter; scuto-scutellum (*ss*) extending to the posterior margin of the segment carrying a pair of low scansorial ampullae; alar area (*a*) simple, not divided; pleural region (*pl*) indistinctly limited above and below; sternal region indistinctly divided by a transverse groove; a small spiracle on each side near anterior dorsal margin.

Second to eighth abdominal segments (fig. 8, D and L) subquadrate. Scuto-scutellum (*ss*) forming a large, unpaired scansorial area without definite ampullae, [illegible] transverse postscutellar area (*ps*); alar area divided into an anterior (*a'*) and posterior (*a''*) portion by a vertical groove which extends to and is confluent with or almost confluent with the groove limiting the postscutellum anteriorly; spiracle situated in lower corner of anterior portion of alar area; pleural region (*pl*) elongate, subrectangularly rounded in outline, very distinctly limited above and below by an upper and lower deep groove; sternal region divided into two parts by a deep transverse groove, lacking only in the eighth abdominal segment, [illegible] transverse scansorial band.

Ninth abdominal segment [illegible] broadest anteriorly, without spiracle; grooves and areas not so distinct as in [illegible].

Tenth abdominal segment [illegible] rower than ninth; anal opening linear, vertical, marked at each end dorsally and ventrally by a dark chitinous speck; anal lobes two in number, large [illegible].

Spiracles (fig. 8, H and J) [illegible] supported by numerous branched small bars and situated posterior to the spiracular opening both in mesothorax and abdomen. Mesothoracic spiracular plate (fig. 8, J) large, about as long as the distance between the dorsal and ventral articulations of the mandible, kidney-shaped with concave margin facing forward. Abdominal spiracles (fig. 8, H) small, about equal to the circumference of the first antennal joint, spiracular plate mytiliform or heart-shaped, broadest anteriorly with a posterior smooth, flat, subtriangular enlargement of the margin.

DIFFERENCES BETWEEN LARVAE OF MALI AND FEMORATA

In the larva of *Chrysobothris mali* a rudimentary ocellus is present on each side behind the antenna; in *C. femorata* none. The prothorax is transversely ovate in *C. mali*, more rounded and comparatively longer in *C. femorata*; the asperities of the prothoracic dorsal and ventral shields are [illegible] and appressed except near the margin in *C. mali*, but conical, granulate, and more prominent in *C. femorata*; the apex of the V-shaped marking of the dorsal shield terminates in the aspersate surface in *C. mali* but reaches the anterior margin in *C. femorata*, and the sides of the marking tend to diverge evenly in *C. mali* but produce a flare at the base in *C. femorata*; the I-shaped marking of the ventral shield is narrower in *C. mali* than in *C. femorata*. Finally the abdominal spiracles have a heart-shaped or trilobed respiratory plate with less than 12 "holes" and the posterior margin is smooth and subtriangularly excised in *C. mali* but a broadly oval and somewhat larger plate with more than 20 "holes" in *C. femorata*. (Fig. 8 and fig. 9, A–F.)

THE PUPA

Flattened, compact, soft, translucent white at first, later taking on color of adult; texture smooth and shiny; antennae, mouth parts, wings, and elytra folded against ventral surface; head, especially mouth parts, resting on prosternum; antennae extending obliquely caudad and resting closely against sides of prothorax; prothoracic and mesothoracic legs with femora and tibiae folded together and extending at right angles from the median line; anterior tarsi resting on the middle coxae and along mesosternum, middle tarsi resting along the metasternum; posterior femora extending at right angles to median line, posterior tibiae extending obliquely caudad along ventral surface of first abdominal segment, posterior tarsi extending to caudal margin of third abdominal segment; the elytra and wings remain short until the pupa changes to the adult; the elytra extend slightly caudad of the posterior margin of the second abdominal segment, the wings extend to the anterior margin of the third abdominal segment. Eight abdominal segments are indicated on the ventral side and ten on the dorsal. (Fig. 9, G and H.)

DIFFERENCES BETWEEN PUPAE OF MALI AND FEMORATA

Recently changed pupae of *mali* and *femorata* are difficult to distinguish. As the development proceeds, however, the pupa takes on the characters of the adult, and *mali* is distinguished by the lobed prosternum and the femoral teeth with smooth basal margins. Usually the larval skin is found with the pupa and it furnishes additional characters to confirm the determination of the species.

HABITS

LARVA

In emerging the young larva bites out most of the bottom of the eggshell and mines directly into the bark. The first borings from the bark are packed into the eggshell and this continues until the shell is filled and the larva has mined deeply enough into the bark to have sufficient space to pack the borings in the mine.

MINING

In mining (fig. 3, B, C, and D; fig. 10, A–F), the larva lies with its dorsal side next to the wood and its abdomen in a semicircular curl. Using its abdomen as a lever, it swings the head and thorax in a semicircular sweep, biting out the cambium, bark, or wood. The

waste material and the excrement are packed in the mine behind the larva. The packing is done as the larva moves around in the mine. Until the larva is full grown practically all of the mining is done in the cambium. When it becomes full grown it bores directly into the wood and forms a slightly enlarged oval cell for pupating and trans-

Fig. 10.—Larvae of the [illegible] eggshells on wood of old [illegible] Raphiolepis, natural size [illegible] entrance to pupal cell [illegible] Pacific flathead borer in mines under the bark of [illegible] larva of the common flat-headed borer [illegible] the wood, × 2 2; E, prepupal [illegible] × 1 4; F, prepupal larvae and pupae in trunk of a young [illegible] tree, × 1 4

forming into the beetle. The entrance to this cell is plugged with the borings from the wood.

The mines wind about and sometimes spiral and girdle small branches or the trunks of small trees. In roses, blackberries, and similar plants the mines often occur in the pith. In these cases the pupal cell is made in the pith and usually is partitioned off from the mine at each end with plugs of borings.

PUPATING

Soon after the pupal cell is formed (fig. 8, C and D; fig. 10, B, E, and F) the larva becomes yellow and much shorter. The interior contents liquefy and the pupa forms from this material. When the pupa becomes fully formed the larval skin splits on the anterior portion and the movements of the pupa work it backward and off the posterior portion, where it is packed in the pupal cell.

PUPA

TRANSFORMING

At first the pupa is pure white and the outer covering is very delicate and easily broken. In a few days the eyes commence to darken and to harden, and soon other parts of the head, thorax, and ventral plates of the abdomen do the same. The elytra, wings, and dorsal portion of the abdomen remain white until transformation to the adult takes place. When the time for this arrives the pupal skin splits and the young adult works it off by moving its legs and other appendages. As soon as the pupal skin is off the elytra, they and the wings move to the dorsal surface and cover the abdomen. The elytra, which are still white at this time, soon take on the color of the mature adult.

ADULT

EMERGING

Until it is fully colored and hardened the young adult remains quietly in its cell. Then it starts moving about and finally mines out to the surface of its host. In emerging the young beetle mines through the plug at the entrance to the pupal cell and then through the bark covering it. The emergence hole is elongate oval and just large enough to allow the beetle to emerge. In making it the beetle revolves in the mine and bites out small pieces of bark, enlarging the hole slowly as it proceeds.

LOCOMOTION

As soon as the beetle emerges it is able to crawl or fly perfectly and can run rapidly over the bark or leaves and fly faster than a man can run. All of these motions are performed best during the warmer parts of the day. Early in the morning or late in the evening the beetle is sluggish and more easily captured. Often a beetle will rest quietly in one spot for a long time, but just as soon as it is disturbed it runs rapidly to the other side of the leaf or branch or flies away. Usually after flying for a short distance it alights on a leaf, branch, or pile of wood and rests quietly as before.

FEEDING

Although food probably is not necessary to sustain life in the beetle stage of this insect, the beetle does feed. It prefers leaves or the tender bark of young twigs, but will eat the older bark and wood, or even paper or cotton. Beetles kept in cages appear to live as long without food as with it.

MATING

The male will pursue the female over a leaf, around a branch, or along the bark of a log until finally, if successful, he catches her. Copulation may last for five minutes but is usually over in one to two minutes. If the pair are disturbed they generally separate quickly and either fly away or drop to the ground.

OVIPOSITION

The eggs are laid on the bark of the host plant (fig. 7, A, D), sometimes in the open but more often flattened down into some crevice or depression or partially hidden by a scale or roughening of the bark. They are laid singly, but sometimes several are laid close enough together to form a group. When ovipositing, the female crawls slowly over the bark and feels down into the crevices and other places with her ovipositor until she finds a suitable place, when she slowly deposits an egg, which is pressed into place by the ovipositor and covered with a viscid secretion which causes it to stick there.

SEASONAL HISTORY

The great majority of the borers of *Chrysobothris mali* overwinter as prepupal larvae in the pupal cells in the outer wood. A few become full grown larvae and enter the prepupal stage by the middle of August. The great majority, however, make this change between the first of September and the last of October. Some remain as prepupae until June, or in higher altitudes until the last of July. Some evidence indicates that a few may remain as prepupae until the second spring. A few specimens overwinter as feeding larvae in the mines beneath the bark, but no pupae or young adults have been found in the pupal cells during the winter.

Pupation starts about the middle of March and continues until the middle of June, a few stragglers running over to the end of July. The great majority pupate between April 15 and May 15.

Transformation to the young beetle starts about the first of April and ends about the middle of July, a few stragglers continuing into August. Most of the beetles caught flying in the field were taken in June and July, and in these months the majority of the eggs are laid.

All of the observations made indicate that the life cycle takes one year at the lower and medium elevations. A few observations taken at higher elevations in the Sierras indicate that at greater altitudes there may be in some cases only two generations in three years.

NATURAL ENEMIES

On the whole it may be said with fairly definite assurance that *Chrysobothris mali* is not greatly checked by its natural enemies. Out of 151 infestations studied, the work of natural enemies was noted in 49. At times, in certain localities and under favorable conditions, however, entire broods of *C. mali* are almost completely destroyed by natural enemies. From the standpoint of man, the circumstances under which these conditions occur are such as to benefit him very little. Most of the damage done by *C. mali* to cultivated

plants is done by scattered individuals, a few to each plant, while the natural enemies of *C. mali* do their greatest work where the larvae of *C. mali* are concentrated in larger wind-fallen trees and under forest conditions.

BIRDS

Infested trees usually show very little evidence of bird work. In several instances noted, however, birds had removed all of the larvae from the pupal cells as well as from the larval mines under the bark. Such observations as "birds apparently have helped considerably in keeping Chrysobothris down," and "birds have dug out a great number of the insects, even from the pupal cells" occur occasionally in field notes. In no instance has the bird actually been seen destroying the insects. It is possible that the western sapsuckers may destroy some of them. It should be observed that all of the notes refer to the taking of the immature stages of *C. mali*. What effect the birds have on the adult insect population is not known. The Bureau of Biological Survey reports 13 species of birds known to feed upon adult Chrysobothris, although none of the records are definitely for *C. mali*.

OTHER PREDATORS

Insect predators that feed on *C. mali* are scarce. No clerids, trogositids, or elaterids were seen. Mites appear to be the most important. In one heavy infestation of *C. mali* in a currant field near San Lorenzo, Calif., in 1918, a large part of the brood was infested by the mite *Pediculoides ventricosus* Newp. (Fig. 11, D.) Numerous *C. mali* beetles emerged early in the season, but most of the later developing brood was killed by the mite. In another infestation in loquat near Los Gatos, Pediculoides killed most of the later developing brood. Chamberlin (2) gives this species of mite as the most important natural enemy of *C. mali* in Oregon.

In one infestation in Los Gatos an asilid fly maggot was found feeding on the larva of *C. mali*. This maggot died without reaching maturity and could not be identified.

PARASITES

Six species of hymenopterous parasites have been observed feeding on the larva of *C. mali*. Two of these are braconids, one is an evaniid, one an ichneumonid, one a tetrastichid, and one a chalcid. The most important is the chalcid *Trigonura californica* Rohwer (fig. 11, A), which was noted in 29 of the 49 cases studied. The next in importance is a braconid, which was noted in 18 cases. The ichneumonid (fig. 11, B) was noted in 6 cases, the tetrastichid (fig. 11, C) in 4, the evaniid in 1, and the second braconid in 1.

In one locality near Edenvale, Calif., a number of eggs were destroyed by a small black chalcid fly. (Fig. 11, E.) So far this species has not been noted in any other locality.

ASSOCIATES

In newly planted trees, where *Chrysobothris mali* does the most damage, it usually works by itself. In older trees, especially those

blown or cut down, it sometimes works with other species of borers. The most important of these associates are the common flat-headed apple-tree borer of the East (*C. femorata*) and the willow Agrilus (*Agrilus politus* Say). It is also found with the alder Agrilus (*A. burkei* Fisher) and the western cottonwood Agrilus (*A.* [illegible]

FIG. 11.—Parasites of the Pacific flathead borer. A, [illegible] parasitized by larva of the chalcid parasite *Tr*[illegible] larva of an ichneumonid parasite in pupal cell of *C.* [illegible] tetrastichid parasite in pupal cell of *C. mali*, × 2; D, [illegible] with mites, Pediculoides sp., × 3.2; E, [illegible] *C. mali*, × 3.2; F, section of apricot wood showing [illegible] two containing normal prepupal larvae, two containing [illegible] parasitized by *T. californica*, and one containing a prepupal [illegible] by Pediculoides, × 1.3

densis Horn). So far it has not been found working with the lepidopterous borers such as the peach borer (*A*[illegible] Hy. Edw.) and the peach-twig borer (*Anarsia lineatella* Zell.). Neither has it been observed to follow the work of any of the roundhead borers such as *Xylotrechus nauticus* Mann. or *Neoclytus conjunctus* Lec. It has been found in the wood with the black fruit-tree weevil

(*Magdalis gracilis* Lec.), but in every case the Magdalis attack appeared to follow the attack of *C. mali.*

Chrysobothris femorata has been found associated with *C. mali* in dying prune and willow trees. In one block of infested Lombardy poplar trees *C. femorata* was found in the trees which were nearly dead whereas *C. mali* was found in those which were more vigorous. In all cases *C. mali* appears to prefer the more vigorous trees whereas *C. femorata* appears to prefer those that are declining, or at least at a standstill.

Agrilus politus is found with *C. mali* in dying willow. Apparently both species attack at the same time, the Agrilus in the small branches and the Chrysobothris in the trunk and in the lower branches.

Agrilus burkei associates with *C. mali* in a similar manner to *A. politus*, but only occasionally. It attacks only the alder, which *C. mali* rarely attacks. In one case observed the Agrilus was killing the alder when the *C. mali* attacked it.

Agrilus granulatus attacks and kills the various poplars. In one infested tree which appeared to be dying from an attack of *A. granulatus*, a larva of *C. mali* was found under the bark of the main trunk.

Magdalis gracilis was found associated with *C. mali* only in the drupaceous fruit trees, such as the prune and cherry. In these cases *C. mali* appeared to have attacked and injured the trees first. As soon as they started to decline the Magdalis attacked and appeared to be completing the destruction.

In his work with the cable beetle (*Scobicia declivis* Lec.) the writer has had considerable wood of various kinds in rearing cages. Sometimes *C. femorata* beetles have been reared from this but never a *C. mali* beetle. This indicates that *C. mali* does not attack this partially seasoned material, and this is the reason why it is not found associated with many of the secondary insects which attack the same host plant.

METHODS OF CONTROL

SELECTION OF STOCK

Plant only sound, vigorous trees. The planting, irrigation, cultivation, pruning, and other care of a first-class tree costs no more than for an inferior tree, and the returns in beauty, fruit production, and general satisfaction are immeasurably greater. If a strong, vigorous, healthy tree is attacked by the flathead borer it has a much better chance of overcoming the attack than a weak tree. Some trees are weakened by an attack in the nursery, and care should be taken to see that none of these are transplanted to other places, as there is also danger of introducing the pest into a locality where it is not present.

PROPER PLANTING

The next problem after selection is planting, and much of the future welfare of the tree depends upon how this is done. The hole should be large enough to give all of the roots plenty of room and the soil which is placed around them should be fertile and in good

condition. The tree should be planted at the same depth as it was planted in the nursery, or perhaps a little deeper. When it can be determined also, the same side of the trunk should face the sun, otherwise the bark might be so tender that it would be sunburned and possibly thus attract the borer.

GOOD CULTIVATION

Proper cultivation, irrigation, drainage, pruning, and other care will help to keep the tree vigorous and in condition to overcome a borer attack, as well as to make it the ideal tree the owner has in mind when planting.

Fig. 12.—Yucca tree protector.

PROTECTION FROM WOUNDS

Borer attacks often start from wounds in the bark made during planting or cultivation. Any wound in the bark of the trunk should be treated as soon as noticed by trimming off the rough edges and giving the wound thus made a coat of good tree paint. In case of severe injury the tree should be stimulated by cultivation and fertilization to make a quick, strong growth.

SHADING

The opinion commonly held is that most of the borer injuries start from sunburn wounds on the trunk. This hardly seems true, however, for newly planted trees which have not had a chance to become sunburned are attacked more than others. The writer is of the opinion that the attack is due more to the fact that the trunk is not shaded and that the sun-loving beetle seeks those trees which have their trunks most exposed to the bright sunshine. Whatever the cause, shading the trunk or other exposed part by proper pruning, by the use of mechanical protectors, or by other means should eliminate this danger. Where practical, trees should be headed low so that the foliage will protect the trunk. Where the damage is most severe in newly transplanted trees some kind of a protector should be used. The best of these is made from the flower stalks of the California yucca (*Yucca whipplei*). (Fig. 12.) Protectors made from wood veneer and from the paper mattress used in printing offices are also good. Brooks (1) recommends the placing of a board in the ground so that it will shade the south side of the tree. It is also possible that some cover crop could be grown that would shade the trunks of the trees during the flight season of the beetles. After it has served this purpose, this crop may be plowed under for fertilizer.

Sunburn and other injuries resulting from climatic conditions may be eliminated to some extent by whitewashing the trunks, by using yucca or other types of tree protectors, and by protecting trees from the effects of drought. As most of the sunburn and climatic wounds are caused during the winter, whitewashing to prevent them should be done during the late fall.

REPELLENTS

In the fight against various borers a number of repellents have been recommended from time to time to prevent the beetle from laying its eggs on the trees. In 1856 Fitch (17) recommended that the trunks and larger limbs be whitewashed or rubbed with soft soap to keep the common flathead borer away. Walsh (33) in 1868 reported that common soap rubbed on about the last of May was a perfect repellent for this species. In 1875 Riley (29) advised coating the trees with soap toward the end of May and again in July and August, or painting with soap, lime, and Paris green.

Since that time most of the economic entomologists have recommended the use of whitewash. Others, however, have recommended an alkaline wash composed of soap, caustic potash, washing soda, naphthalene, flour, cement, and sometimes crude carbolic acid, lime, and a poison like Paris green. Brooks (5) recommends white-lead paint as one of the best repellents. Matheson (23) used an emulsion of carbolineum, a refined creosote product, in fighting the willow and poplar borer. Chapman (10) used a spray of lime sulphate and iron sulphate or Bordeaux mixture on the trunks of oak trees to keep off the two-lined chestnut borer.

Ordinary whitewash is the remedy commonly recommended in the Pacific States. It undoubtedly does some good, but usually a few beetles get in, and often it has little effect. This is well illustrated by the following extract from a letter received from the western foothills of the Sierras:

> After setting out the orchard (in February) I immediately whitewashed every tree with a mixture of lime and bluestone, and when the seasonal rains occurred thereafter a new application was given as soon as the trees dried off sufficiently to admit applying same. The last rain of the season was on June 10. Every tree in the orchard was attacked * * * Some of the trees had as many as 15 grubs in them.

That the complex washes and paints are not much better than the regular whitewash is shown by the following experiments made by the writer: April 12, 1923, 70 trees out of a row of 135 flowering pear and 53 trees out of a row of 106 flowering apple were treated with a recommended flour, naphthalene, potash-soap, and water wash. November 5, these trees were examined and 8 treated and 8 untreated pear and 9 treated and 6 untreated apple trees were found infested. February 1, 1924, 196 apple trees were painted with a cold water paint and planted in the orchard. All of these trees had been attacked by the borer and were dying when examined September 19.

PREVENTION OF OVIPOSITION

Besides the paper matrix and the yucca and veneer protectors whose uses have already been mentioned, wire screen, burlap, or paper have been wrapped around the trunks of trees to prevent the beetle from

laying its eggs on the bark. In the Pacific States the opinion is held that wrapping the trunk of the tree with anything like paper or burlap is injurious, and that wire screening is more expensive and not so good as the yucca, paper matrix, or veneer protectors.

The writer's experiments indicate that the yucca protector is the most satisfactory. The cost is reasonable; the texture is porous enough to permit a free circulation of air; and the color and wearing qualities are good. Last but not least, efficient protection is given. One orchardist, who had every tree of a planting attacked in 1922, used yucca protectors in 1923 and wrote as follows in 1924: "Results, 150 trees treated; attacks none. Bark on trees smooth and healthy. Trees in fine condition." Other orchardists report similar results.

Kannan used the following method in fighting the Indian coffee borer (*Xylotrechus quadripes* Chevr.), which deposits its eggs beneath the scales of the bark. He scrubbed the trees about the time of oviposition so that the trunks would be smooth and the beetle could find no place in which to oviposit. As the adult of the flathead borer is able to lay its eggs on smooth bark, this method of control offers little encouragement to the California tree owner.

OVICIDES

Various substances have been used at different times to destroy the eggs of injurious insects. McIndoo, Simanton, Flank, and Enke (27) used 40 per cent nicotine sulphate at 1 to 400 and 1 to 800 parts of water on codling-moth eggs, but without great success. Lovett (25) tried the same at 1 to 400 and 1 to 1,200 parts of water, and at the proportion of 1 to 1,200 with the addition of fish-oil soap (4 pounds to 100 gallons) obtained perfect control with a small number of eggs; but without the soap only 80 to 85 per cent of the eggs were destroyed. Stearns (37), in experiments on the eggs of the oriental peach moth, used the 40 per cent nicotine sulphate at 1 to 800 parts of water, with a spreader of either 1 pound of lime-casein mixture (casein 1 part, hydrated lime 3 parts) to 50 gallons of water, or 4 pounds of sea moss to 50 gallons of water. The writer used carbolineum on the eggs of the flathead borer, but without effect.

LARVICIDES

Many of the substances mentioned under repellents are supposed to have some larvicidal action. Brooks (4) considers white-lead paint to be one of the best of these. Craighead (10) recommends a kerosene and sodium-arsenate emulsion. Snyder (37) used a modification of this in which miscible oil took the place of the kerosene to control the casuarina borer (*Chrysobothris tranquebarica* Gmel.). Hopkins (20) used a strong dilution of kerosene emulsion to kill the young larvae of the locust borer (*Cyllene robiniae* Forst.), and Chittenden (17) recommends the application of kerosene wherever the castings of the roundheaded apple-tree borer (*Saperda candida* Fab.) protrude from the bark. Matheson (28) reports excellent success in killing the larva of the poplar and willow borer (*Cryptorhynchus lapathi* L.) by the use of carbolineum. The writer used carbolineum in several instances, but the young flathead borers went through the carbolineum and entered the bark as usual.

WORMING

From the earliest attempts at control the killing of the borers by probing with a wire or cutting out with a knife has been recommended. In 1856 Fitch (*17*) wrote that trees infested with the common flathead borer should be inspected during August and September and the borers killed with a pin or cut out. From time to time other writers have recommended the same treatment, and as late as 1919 Brooks (*4*) recommended it for the treatment of newly planted trees during the summer before the borers have had time to make deep wounds in the wood. This method has been found to be one of the best to use against the Pacific flathead borer. The writer has tried it in beech at Los Gatos and in cherry and plum in San Jose with excellent results. One apple-orchard owner says: "Every tree in the orchard was attacked and all would have been killed had I not removed the grubs from the tree with sharp-pointed instruments."

PRUNING

In the case of currants and shrubs it is probable that the best method of control is to cut out the infested parts and destroy them or place them in cages so that the parasites may escape while the beetles are trapped and killed.

POISON SPRAYS TO KILL BEETLES

As the beetles feed on the foliage and outer bark of the trees on which they lay their eggs, it seems reasonable to suppose that a poison spray might destroy numbers of them. This suggested to the earlier writers the mixing of Paris green in the various repellent washes. Some of the later writers have used arsenical sprays for this same purpose. Brooks (*5*) says that such sprays will kill the beetles of the roundheaded apple-tree borer and the spotted apple-tree borer. Snyder (*57*) recommends spraying the trunks of the casuarina trees from April to June with a poison miscible-oil spray to kill the beetle of the casuarina borer. At the present time there is no record of this method being tried for the control of the Pacific flathead borer.

TRAPS

FOR ADULTS

As the beetles fly from place to place after they emerge and examine all sorts of trees and logs, Brooks (*4*) has suggested for the control of the common flathead borer that poles be set up throughout the orchard and covered with some sticky material which will entangle them when they alight.

EGG TRAPS

Chittenden (*21*) suggests that logs, branches, and tops of favored host plants should be scattered around the outskirts of the orchard. These attractive egg laying places would keep the beetles from laying on the trees and could be destroyed with the infesting insects at the close of the season.

COLLECTION OF ADULTS

Koebele (*24*), in the first published reference to the Pacific flathead borer as an injurious insect, recommended the collection and destruction of the beetles during the early morning and late evening while they are inactive. At this time they rest on and within dry and dead leaves from which they can be shaken into an umbrella or other receptacle. Fitch (*17*) recommended this time for collecting the common flathead borer in 1856.

RAPID MOVEMENT OF NURSERY STOCK

The greatest losses in the nursery occur in stock held over for several years. Borer work would be greatly reduced if the older stock was sold first. It appears to be more susceptible to the borer attack and also produces broods of beetles which reinfest it as well as the new stock.

ELIMINATION OF BREEDING PLACES

Any kind of newly cut, fallen, or dead trees in which the beetles live should be destroyed in the spring before the adults emerge from them. This refers to prunings, orchard trees, shade trees, and traps, as well as wild hosts. A large fallen branch of sycamore along a creek bank may produce enough beetles to stock many acres of young orchard trees with borers. The same is true if a quantity of infested culls from a nursery is piled and left without treatment.

DEVELOPMENT OF RESISTANT TREES

In the future there may be a possibility of breeding up a resistant stock. Groups of trees are often found in which nearly every member of the group will be attacked time after time while one or two members will not be attacked at all. Out of a row of five silver maple street trees in Los Gatos one was killed at the first attack, one at the second, two survived three attacks, and the fifth was not attacked at all. About the same conditions prevailed in a group of copper beech in a park. Most of the trees had been attacked several times, but one member of the group escaped all attacks. There must be some inherent reason for this. Probably such a tree can pass this resistant quality on to its descendants.

SUBSTITUTION OF IMMUNE TREES

If it is impossible to find resistant trees of the desired variety, and the borers continue to cause trouble, which they will do at certain times in certain localities in spite of the recommended control measures, the best thing to do is to plant other varieties of trees which, so far as known, are not attacked by the borers. Some of these are the black walnut (*Juglans nigra* and *J. californica*), chestnut (*Castanea dentata*), hackberry (*Celtis occidentalis*), California laurel (*Umbellularia californica*), sweet gum (*Liquidambar styraciflua*), English hawthorn (*Crataegus oxyacantha*), honey locust (*Gleditsia triacanthos*), black locust (*Robinia pseudoacacia*), acacias

(*Acacia decurrens* and varieties), basswood (*Tilia americana*), European lindens (*T. platyphyllos* and *T. tomentosa*), empress tree (*Paulownia imperialis*), maiden-hair tree (*Ginkgo biloba*), and various conifers.

RECOMMENDATIONS

The control experiments carried on by the writer and his associates, and numerous observations made in parks and orchards where various methods of control have been tried, indicate that the following methods are best in central California:

The first and safest method is to protect all transplanted trees for the first three or four years with yucca tree protectors. (Fig. 12.) The protector should be of the proper length to cover the trunk of the tree below the lower branches, and it should be attached carefully, the lower end being forced down into the soil for at least 1 inch.

Next to this method, the writer would recommend the cutting out of the young borer before it has had time to do any serious damage. All trees should be examined carefully about the middle of June, again in the middle of July, and finally about the last of August. All wounds made in the bark in carrying out this treatment should be covered with a good protective tree paint or grafting wax.

All observations indicate that little dependence can be placed upon the use of any of the repellents, poisoned washes, ovicides, or larvicides thus far developed. Many of them do some good, but none reduce the amount of infestation enough to make it safe to discontinue worming or the use of mechanical protectors.

In the nursery the best method of eliminating losses is to keep the stock in good condition and moving. Most of the borer damage to nursery stock occurs in stock held over for several years.

The elimination of all possible breeding places in or near the orchard should be included in connection with any other method of control used.

SUMMARY

One of the most injurious pests of shade trees and ornamental trees and shrubs on the Pacific coast is the Pacific flathead borer, *Chrysobothris mali* Horn. This species attacks and kills, or seriously injures by girdling the main trunk, over 55 species of ornamental plants. It also seriously injures some of the more valuable fruit trees, such as the apple, pear, peach, plum, apricot, and prune.

The Pacific flathead borer is the larva of a beetle belonging to the family Buprestidae, which are known as metallic woodborers. During the spring and early summer the mother beetle lays the eggs on the bark, or in a crevice of the bark, of the main trunk or branches of the plant attacked. In a few weeks the young larva emerges by boring through the shell of the egg into the bark. Mining back and forth through the inner bark, it feeds and grows for six or eight weeks until fully developed. It then mines into the outer wood and forms a pupal cell, where it lies quiescent until the following spring. Sometime between the middle of March and the middle of June the borer pupates and in from three to five weeks transforms to a young beetle. This rests in the cell for a week or two until fully mature, when it gnaws its way out to the surface, where it meets

others of its kind and mates. The female lays eggs on the bark, and the life cycle is complete.

The best method of protecting trees from the attacks of the Pacific flathead borer is to use the yucca tree protector, which keeps the female beetle from depositing her eggs on the bark of the main trunk. After a tree is attacked by the borer the best method of saving it is to cut out the borer with a sharp knife. This should be done in the late spring or early summer before the borer completes its growth. Otherwise the injury may become serious and the plant may not be able to survive.

LITERATURE CITED

(1) ALLEN, E. W.
1891. REPORT OF THE SECRETARY. Oreg. Bd. Hort. Bien. Rpt. 1: 39-56, illus.

(2) ———
1893. REPORT OF THE SECRETARY. Oreg. Bd. Hort. Bien. Rpt. 2: 66-105, illus.

(3) BLACK, P. C.
1921. REPORT OF DISTRICT AGRICULTURIST AND FIELD INSPECTOR, GRAND FORKS. Brit. Columbia Dept. Agr. Ann. Rpt. (1920) 15: Q 45-Q 46.

(4) BROOKS, F. E.
1919. THE FLAT-HEADED APPLE-TREE BORER. U. S. Dept. Agr. Farmers' Bul. 1065, 15 p., illus.

(5) ———
1920. ROUNDHEADED APPLE-TREE BORER: ITS LIFE HISTORY AND CONTROL. U. S. Dept. Agr. Bul. 847, 42 p., illus.

(6) BURKE, H. E.
1917. NOTES ON SOME WESTERN BUPRESTIDÆ. Jour. Econ. Ent. 10: 325-332.

(7) CHAMBERLIN, W. J.
1917. NOTES ON SOME BUPRESTIDÆ OF NORTHERN CALIFORNIA (COL.). Ent. News 28: 129-139, illus.

(8) ———
1920. DESCRIPTION OF ONE NEW BUPRESTID WITH NOTES ON OTHER LITTLE KNOWN SPECIES (COLEOP.). Ent. News 31: 241-244, illus.

(9) ———
1921. FLAT-HEADED BORERS WHICH ATTACK ORCHARD TREES AND CANE FRUITS IN OREGON. Oreg. Agr. Expt. Sta. Crop Pest and Hort. Rpt. (1915/20) 3: [103]-108, illus.

(10) CHAPMAN, R. N.
1915. OBSERVATIONS ON THE LIFE HISTORY OF AGRILUS BILINEATUS. Jour. Agr. Research 3: 283-294, illus.

(11) CHITTENDEN, F. H.
1907. THE LARGER APPLE-TREE BORERS. U. S. Dept. Agr., Bur. Ent. Circ. 32, 11 p., illus. (3d revision.)

(12) COCKERELL, T. D. A.
1902. NOTES FROM NEW MEXICO AND ARIZONA. U. S. Dept. Agr., Div. Ent. Bul. (n. s.) 37: 107-109.

(13) COOK, A. J.
1896. THE BURPRESTID BORERS. Rural Californian 19: 66.

(14) ———
1896. INSECT BORERS. Calif. Cult. and Poultry Keeper 10: 362, illus.

(15) ———
1896. THE CALIFORNIA BIG HEADED BORER. Calif. Cult. and Poultry Keeper 10: 362-363.

(16) CRAIGHEAD, F. C.
1915. A NEW MIXTURE FOR CONTROLLING WOOD-BORING INSECTS—SODIUM ARSENATE-KEROSENE EMULSION. Jour. Econ. Ent. 8: 513.

(17) FITCH, A.
1856. THE THICK-LEGGED BUPRESTIS, OR SNAPPING-BEETLE, CHRYSOBOTHRIS FEMORATA, FABRICIUS. In his Report on the Noxious, Beneficial, and other Insects of the State of New York [for 1854], p. 25-31, illus. Albany.

(18) GIBSON, A.
1912. THE ENTOMOLOGICAL RECORD, 1911. Ent. Soc. Ontario, Ann. Rpt. (1911) 42: 89–112.
(19) HENDRICKSON, A. H.
1921. PRUNE GROWING IN CALIFORNIA. Calif. Agr. Expt. Sta. Bul. 328, 38 p., illus.
(20) HOPKINS, A. D.
1910. ADDITIONAL DATA ON THE LOCUST BORER. U. S. Dept. Agr., Bur. Ent. Bul. 58: 31–40.
(21) HORN, G. H.
1886. MONOGRAPH OF THE SPECIES OF CHRYSOBOTHRIS INHABITING THE UNITED STATES. Amer. Ent. Soc. Trans. 13: 65–124, illus.
(22) HORNE, W. T., and ESSIG, E. O.
1921. PLANT DISEASE AND PEST CONTROL. Calif. Agr. Expt. Sta. Circ. 227, 69 p.
(23) ——— ESSIG, E. O., and HERMS, W. B.
1923. PLANT DISEASE AND PEST CONTROL. Calif. Agr. Expt. Sta. Circ. 265, 103 p.
(24) KOEBELE, A.
1890. REPORT ON CALIFORNIA INSECTS. U. S. Dept. Agr., Div. Ent. Bul. 22: 85–94.
(25) LOVETT, A. L.
1918. NICOTINE SULPHATE AN EFFECTIVE OVICIDE FOR CODLING MOTH EGGS. Jour. Econ. Ent. 11: 149–150.
(26) ——— and BARSS, H. P.
1923. INSECT PESTS AND DISEASES OF CURRANTS AND GOOSEBERRIES. Oreg. Agr. Expt. Sta. Circ. 42, 12 p., illus.
(27) MCINDOO, N. E., SIMANTON, F. L., PLANK, H. K., and FISKE, R. J.
1921. EFFECTS OF NICOTINE SULPHATE AS AN OVICIDE AND LARVICIDE ON THE CODLING MOTH AND THREE OTHER INSECTS. U. S. Dept. Agr. Bul. 938, 19 p.
(28) MATHESON, R.
1917. THE POPLAR AND WILLOW BORER. N. Y. Cornell Agr. Expt. Sta. Bul. 388, p. 457–483, illus.
(29) RILEY, C. V.
1875. THE FLAT-HEADED APPLE-TREE BORER—CHRYSOBOTHRIS FEMORATA (FABR.). *In* Seventh Annual Report on the Noxious, Beneficial, and other Insects of the State of Missouri, p. 71–79, illus. Jefferson City.
(30) SNOW, F. H.
1904. LISTS OF COLEOPTERA, LEPIDOPTERA, DIPTERA AND HEMIPTERA COLLECTED IN ARIZONA BY THE ENTOMOLOGICAL EXPEDITIONS OF THE UNIVERSITY OF KANSAS IN 1902 AND 1903. Kans. Univ. Sci. Bul. 2: 323–350.
(31) SNYDER, T. E.
1919. INJURY TO CASUARINA TREES IN SOUTHERN FLORIDA BY THE MANGROVE BORER. Jour. Agr. Research 16: 155–164, illus.
(32) STEARNS, L. A.
1920. SOME RESULTS WITH NICOTINE AND NICOTINE COMBINATIONS IN EXPERIMENTS ON THE CONTROL OF LASPEYRESIA MOLESTA BUSCK. Jour. Econ. Ent. 13: 364–367.
(33) VAN DYKE, E. C.
1916. NEW SPECIES OF BUPRESTIDAE (COL.) FROM THE PACIFIC STATES, WITH NOTES CONCERNING A FEW OTHERS. Ent. News 27: 405–412, illus.
(34) ———
1923. NEW SPECIES OF COLEOPTERA FROM CALIFORNIA. Bul. Brooklyn Ent. Soc. 18: 37–53.
(35) WALSH, B. D.
1866. BORERS. Pract. Ent. 1 (4): [25]–31, illus.
(36) WICKSON, E. J.
1903. THE FLAT-HEADED BORER. Pacific Rural Press 66: 243.
(37) ———
1904. THE FLAT-HEADED BORER. Pacific Rural Press 68: 115.
(38) ———
1904. THE FLAT-HEADED BORER. Pacific Rural Press 68: 259.

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